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63-4-5

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STUDY OF PHYSICAL AND CHEMICAL CHARACTERISTICS
OF BALLOONS AND BALLOON MATERIALS

REPORT NO. 1

U.S. ARMY CONTRACT No.
DA-36-039-AMC-02160(E)

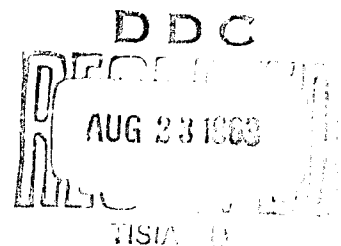
Department of the Army Project No.
LAO - 25001 - A - 126 - 01 - 04

FIRST QUARTERLY PROGRESS REPORT

1 March 1963 - 31 May 1963

U. S. Army Electronics Research & Development Laboratory
Fort Monmouth, New Jersey

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STUDY OF PHYSICAL AND CHEMICAL CHARACTERISTICS
OF BALLOONS AND BALLOON MATERIALS

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U. S. Army Contract No.:	DA-36-039-AMC-02160(E)
SC Technical Requirement No.:	SCL-5205A, 26 Aug 1959 w/Amend. 1, 13 Sep 1961
Department of the Army Project No.:	1AO-2500--A-126-01-04

FIRST QUARTERLY PROGRESS REPORT

Period covered by this report:
1 March 1963 - 31 May 1963

The object of this study is to continue the investigation of physical and chemical characteristics of balloons and balloon materials, particularly new elastomers, as well as flight conditions and their effect on balloon performance.

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Edited by: John Kantor

Kaysam Corporation of America
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Paterson 3, New Jersey

TABLE OF CONTENTS

	<u>Page</u>
PURPOSE.....	1
ABSTRACT.....	2
PUBLICATIONS, LECTURES, REPORTS, AND CONFERENCES.....	6
FACTUAL DATA	
TASK A: PROPERTIES OF BALLOONS AND BALLOON FILMS.....	11
Phase 1: Study of the Literature.....	11
Phase 2: Evaluation of Raw Materials.....	11
Part A: Neoprene Polymers.....	11
Part B: Polymers other than Neoprene.....	13
Part C: Other Materials.....	16
Phase 3: Evaluation of Processing Techniques.....	19
Phase 4: Molecular Structure of Balloon Films.....	23
Phase 5: Development of Optimum Compounds.....	23
TASK B: EFFECT OF FLIGHT CONDITIONS ON BALLOON PERFORMANCE.....	28
Phase 1: Behavior on Inflation and Rupture.....	28
Phase 2: Effect of Pre-Elongation.....	28
Phase 3: Effect of Ozone.....	29
Phase 4: Effect of Radiation.....	31
CONCLUSIONS.....	35
PROGRAM FOR THE NEXT INTERVAL.....	39
IDENTIFICATION OF KEY TECHNICAL PERSONNEL.....	42

PURPOSE

The aims of this study are to improve the performance of meteorological balloons by the use of newly developed neoprene polymers specifically designed for such a purpose, by the use of other basic polymeric materials, by improved compounding and processing, and by a better understanding of atmospheric conditions during flight.

This work will be performed according to the following schedule:

TASK A: PROPERTIES OF BALLOONS AND BALLOON FILMS

- Phase 1: Study of the Literature
- Phase 2: Evaluation of Raw Materials
- Phase 3: Evaluation of Processing Techniques
- Phase 4: Molecular Structure of Balloon Films
- Phase 5: Development of Optimum Compounds

TASK B: EFFECT OF FLIGHT CONDITIONS ON BALLOON PERFORMANCE

- Phase 1: Behavior on Inflation and Rupture
- Phase 2: Effect of Pre-Elongation
- Phase 3: Effect of Ozone
- Phase 4: Effect of Radiation

ABSTRACT

The following is a resume of the work performed during the period from 1 March 1963 through 31 May 1963:

TASK A: PROPERTIES OF BALLOONS AND BALLOON FILMS

Phase 1: Study of the Literature

The study of current literature revealed nothing of interest.

Phase 2: Evaluation of Raw Materials

Part A: Neoprene Polymers

A preliminary conference was held with the personnel of E. I. du Pont de Nemours and Company. The status of new polymer development and the most desirable characteristics of polymers were discussed.

Neoprene 673 was evaluated in a dual-purpose compound.

Part B: Polymers other than Neoprene

Compounds based on blends of neoprene latex and natural latex as well as compounds based on blends of neoprene latex and poly-isoprene latex were evaluated. Room-temperature and low-temperature characteristics were determined in order to measure the effectiveness of poly-isoprene as a low-temperature plasticizer.

Part C: Other Materials

Kadox 515, a fine-particle-size French Process Zinc Oxide, was compared with Kadox 72 which is a somewhat coarser material. Compound stability,

ABSTRACT (continued)TASK A, Phase 2, Part C (continued)

as well as the physical properties of the films, was measured.

Butoxy Ethyl Oleate from American Chemicals was evaluated as a low-temperature plasticizer for neoprene.

Phase 3: Evaluation of Processing Techniques

Preliminary tests were run using felt as a filter medium for removing small agglomerates from balloon compounds in order to eliminate these possible sources of premature rupture. The results were inconclusive, and further work was indicated.

Balloons having an integral neck were prepared, and various means were adopted for closing the opening created at the end of the balloon opposite the neck. Flight tests were conducted with satisfactory results.

Phase 4: Molecular Structure of Balloon Films

A preliminary conference was held with Dr. Herman Newstein to organize the program of X-ray diffraction and electron-microscope studies to be conducted.

Phase 5: Development of Optimum Compounds

Flights were conducted with 1000-gram and 1500-gram and 2500-gram balloons made from a high-elongation compound (A5-101). Very good results were obtained with the 1000- and 1500-gram balloons.

Balloons made from compound A5-102 which contains

ABSTRACT (continued)TASK A, Phase 5 (continued)

Kadox 515 (see Task A, Phase 2, Part C) were flown. The performance was good but little better than that of balloons made from a standard compounds in either altitude attained or consistency of performance.

Balloons weighing 1000 grams manufactured from a compound containing Butoxy Ethyl Oleate were flown with very satisfactory results.

Four balloons weighing approximately 4000 grams were flown. These balloons were made from a standard compound; and the results were encouraging, particularly insofar as consistency of performance is concerned.

TASK B: EFFECT OF FLIGHT CONDITIONS ON BALLOON PERFORMANCEPhase 1: Behavior on Inflation and Rupture

No progress during this period.

Phase 2: Effect of Pre-Elongation

Preliminary tests were conducted to determine the effect of pre-elongation on natural-latex films. The results were inconclusive due to mechanical problems with the test equipment.

Phase 3: Effect of Ozone

The resistance to attack by ozone of compound A5-101, a high-elongation compound, was compared with that of A5-104, a standard compound. The effect of increasing the amount of antiozonant in both compounds was also determined.

ABSTRACT (continued)TASK B (continued)Phase 4: Effect of Radiation

The effect of infra-red radiation on the high-elongation compound A5-101 was studied. Its pattern of behavior was demonstrated to be basically similar to that of compound A5-104.

The effect of infra-red radiation on a natural-latex compound was also evaluated. Testing was restricted to temperatures below -40°C because of the extremely high elongations encountered at higher temperatures, resulting in the jaws reaching the end of their travel before rupture occurred.

Five compounds were designed containing materials meant to reflect infra-red radiation. Physical properties were determined with and without infra-red radiation, and the best compound was selected for future flight testing.

PUBLICATIONS, LECTURES, REPORTS, AND CONFERENCES

No publications, lectures, or reports resulted from this study during the period covered by this report.

CONFERENCES:

February 26, 1963, at the DuPont Laboratories, Chestnut Run, Delaware.

Present were:	Mr. Robert Arnold	DuPont Laboratories
	Mr. Jack Fitch	DuPont Laboratories
	Mr. Donald Gorman	DuPont Laboratories
	Mr. Donald Thompson	DuPont Laboratories
	Mr. George Scott	DuPont Laboratories
	Mr. Eric Nelson	Kaysam Corporation
	Mr. Harding Wing	Kaysam Corporation

The meeting opened with a report from Eric Nelson on the results obtained with the experimental latices submitted by DuPont, and with the commercial latices also evaluated. The importance of the shape of the stress-strain curve was emphasized, particularly as it is related to balloon inflation behavior and flight performance. It was demonstrated and agreed upon by all parties that polymers showing development of a high degree of crystallinity were unsuitable for use in meteorological balloons.

The degree of inflection shown by the stress-strain curve is a measure of the tendency for a balloon to distort during inflation. DuPont, therefore, agreed that they would endeavor to develop a polymer with the high-elongation characteristics already requested which would show this inflection condition to the least possible degree. The complete elimination of the inflection in the stress-strain curve appears to be impossible since this is a characteristic of neoprene.

PUBLICATIONS, LECTURES, REPORTS, AND CONFERENCES (continued)CONFERENCES (continued)

There followed a general discussion on the possibilities of improving the physical characteristics of existing polymers. It was suggested that a combination of the accelerators, Thiuram 'E' and Tepidone, would result in a fast-rising compound which might have better elongation.

The possible use of Thiocarbanilide to provide a low-temperature or room-temperature cures raised the question of what aging characteristics would be expected. It was acknowledged that Thiocarbanilide-cured films will cure progressively on storage, but the extended aging characteristics are not known.

Filtering latex or latex compound through felt or through a sand bed was suggested as a means of improving the clarity and cleanliness of the film. Kaysam representatives felt this was worthy of investigation.

The possibilities of using only liquid compounding ingredients was again raised. Mr. Wing reported on the unsurpassable problems associated with using zinc resinate. Mr. Thompson suggested that Antox might offer a means of eliminating two solid compounding ingredients, i.e., Neozone 'D' and N.B.C., since it is itself a good anti-oxidant and anti-ozonant. Kaysam will evaluate this material for use in balloon film.

The meeting concluded with a summarization by Mr. Arnold of all the points discussed.

PUBLICATIONS, LECTURES, REPORTS, AND CONFERENCES (continued)CONFERENCES (continued)

May 3, 1963, at the U. S. Army Electronics Research and Development Laboratory, Evans Area, Belmar, N. J.

Present were:	Mr. J. LeBedda	USAERDL
	Mr. C. Bastian	USAERDL
	Mr. M. Sharenow	USAERDL
	Dr. H. Newstein	Drexel Institute
	Mr. G. C. Guard	Kaysam Corporation
	Mr. J. Kantor	Kaysam Corporation
	Mr. E. Nelson	Kaysam Corporation

Mr. Sharenow opened the proceedings with a brief resume of the major practical accomplishments for the past two and one-half years. These included the establishment of new altitude records, by both day and night, as well as substantial improvement in the bursting altitude and reliability of production balloons. In addition, the reliability of balloons designed to reach higher altitudes than standard production balloons has also been significantly improved.

Mr. Nelson reported on the latest conference with DuPont personnel regarding the development of new polymers for meteorological balloons. Recent findings have eliminated polymer types which show a high degree of crystallinity. DuPont has recognized the value of this information and is proceeding with the development work in this new light. The presence of a representative from the DuPont research laboratory in Louisville, who made the journey for the purpose of attending this meeting, attests to the interest being shown in this work.

The behavior of crystalline polymers has also highlighted the necessity for gaining more basic knowledge concerning the effect of the molecular structure of neoprene polymers.

PUBLICATIONS, LECTURES, REPORTS, AND CONFERENCES (continued)CONFERENCES (continued)

Dr. Newstein undertook the study of molecular structure by means of x-ray diffraction techniques.

In response to suggestions from Messrs. LeBedda and Sharenow, it was also agreed to make a study of the shapes and sizes of compounding ingredient particles. This study will also be conducted by Dr. Newstein using the electron microscope.

Mr. Nelson stated that, in the meantime, an investigation of the effect of careful straining of latex compounds through felt and the elimination of all solid compounding ingredients other than Zinc Oxide was already under way. Mr. LeBedda suggested that the possibilities of straining through chamois leather should also be investigated, and it was agreed to do this. The possibility of solublizing Zinc Oxide was suggested by Mr. Kantor.

After discussion of the above points, it was agreed that a further conference with the DuPont personnel should be scheduled for the near future.

The photographic study of balloons at burst will be continued with the assistance of Dr. Newstein. It is planned to extend this study to larger balloons.

Mr. LeBedda asked if there were any plans to investigate and develop compounds for use in the Tropical and Arctic Zones. He was assured by Kaysam representatives that this line of research would be included in the study. Mr. LeBedda and Mr. Sharenow discussed the possibilities of heating the gas as

PUBLICATIONS, LECTURES, REPORTS, AND CONFERENCES (continued)CONFERENCES (continued)

the balloon was being inflated, and also the provision of means for heating the gas in the balloon during flights.

A series of flights with aged balloons is being conducted by the Army, and it was suggested by Mr. LeBedda that the results be incorporated in this study.

The recent improvements in performance of balloons at all levels were illustrated. Compounds already developed since the initiation of this contract have produced 1000-gram balloons capable of flying in the 110,000- to 120,000-foot range with good consistency. In addition, a limited number of flights with 1500-gram balloons have reached altitudes in excess of 130,000 feet.

Also, there have been successful flights to almost 140,000 feet with 4000-gram balloons made on a new dipping form and using a standard compound. It seems reasonable to hope that a balloon capable of consistent performance above 140,000 feet will shortly be a reality when the newly-developed compounds are used for this size balloon.

Mr. LeBedda advised that an impending reduction in the cost of hydrogen by the use of field generators will permit the use of larger balloons. Work in the above directions, will, therefore, be vigorously pursued.

FACTUAL DATATASK A: PROPERTIES OF BALLOONS AND BALLOON FILMSPhase 1: Study of the Literature

A study of the current literature has not revealed anything of interest during this quarter.

Phase 2: Evaluation of Raw MaterialsPart A: Neoprene Polymers

A preliminary conference with the personnel from E. I. du Pont de Nemours was held to discuss the status of the development of new polymers. The minutes of this meeting are incorporated in the section on "PUBLICATIONS, LECTURES, REPORTS, AND CONFERENCES" of this report. It was agreed that the nature of the stress-strain curve which is obtained with polymers showing a high degree of crystallinity was undesirable and that there was, apparently, little to be gained by pursuing this line of attack.

The tests previously conducted with Neoprene 673, which is typical of the crystallizing polymers, have all been based on day-flight compounds containing only a small proportion of plasticizer. Before completely abandoning this type of polymer, it was decided to evaluate at least one dual-purpose compound based on Neoprene 673. At the same time, the effect of combining such a polymer with poly-isoprene was also investigated. Two compounds, A2a-1 and A2a-2, were prepared, and their formulations are given in Table 1.

TABLE 1
FORMULATIONS OF COMPOUNDS CONTAINING NEOPRENE 673

Formulation No.	A2a-1	A2a-2
Neoprene 673	100.0	100.0
Poly-isoprene	-	20.0
Zinc Oxide	5.0	10.0
N.B.C.	3.0	3.0
Neozone 'D'	2.0	2.0
Merac	1.0	-
Accelerator 833	-	2.0
Sunaptic Acid	1.0	1.0
Sulphur	-	0.6
Barak	-	0.15
Aquarex SMO	0.5	0.5
Dibutyl Sebacate	10.0	10.0
Butyl Oleate	15.0	15.0

FACTUAL DATA (continued)TASK A, Phase 2, Part A (continued)

Plates were dipped from these compounds and cured for 60 minutes at 260°F. Physical properties were determined after 1 day, 7 days, and 14 days. The results of these tests are given in Table 2.

It is apparent from these results that the crystallizing characteristics of Neoprene 673 are still producing undesirable physical properties even in a dual-purpose compound with high plasticizer content. The addition of poly-isoprene to the compound, while delaying the crystallization, does not eliminate the condition nor does it reduce the condition to an acceptable level.

Balloons weighing 100 grams made from compound A2a-1 showed very uneven expansion upon inflation, and there can be little doubt that sounding balloons made from such a compound would have extremely poor ascensional rates and would reach much lower bursting altitudes than balloons made from compounds containing non-crystallizing polymers.

In order to complete the study, the properties of compound A2a-2 will be determined after 28 days, and the inflation pattern of 100-gram balloons will be observed. However, it seems that the previous conclusions concerning crystallizing polymers are correct and that such polymers cannot be modified by compounding to overcome this deficiency.

TABLE 2

PHYSICAL PROPERTIES OF COMPOUNDS A2a-1 AND A2a-2
TESTED AT ROOM TEMPERATURE AND AT -70°C

Compound No.	Test Temp. (°C)	Interval between Curing & Testing	Modulus at 200% (psi)	Modulus at 400% (psi)	Modulus at 600% (psi)	Tensile Strength (psi)	Elongation at Break (%)
A2a-1	+20	1 day	100	190	510	1780	950
	+20	7 days	200	470	1200	2750	890
	-70	1 day	1940	3320	-	4400	460
A2a-2	+20	1 day	70	110	320	1245	870
	+20	4 days	100	150	450	1600	900
	+20	7 days	130	250	800	1910	850
	+20	14 days	150	360	980	2250	820
	-70	1 day	1570	3220	-	4080	450

FACTUAL DATA (continued)TASK A, Phase 2 (continued)Part B: Polymers Other than Neoprene

It has already been shown in a previous contract (DA-36-039-SC-90747) that Polyisoprene 200 as manufactured by the Shell Chemical Company cannot be used for the manufacture of meteorological balloons because of the gel structure which does not permit its expansion. However, the excellent low-temperature characteristics of both poly-isoprene and natural rubber suggest that these materials might have merit as polymeric, low-temperature "plasticizers."

The instability of natural latex and neoprene latex blends is well known, and an experimental compound consisting of a standard balloon compound and deammoniated natural latex showed the presence of hard coagulum after 30 days. Poly-isoprene latex, being synthetic, would appear more likely to be compatible with neoprene latex, and initial tests indicated that this was so.

Therefore, a series of compounds was prepared by successively adding sulphur, butyl oleate, and poly-isoprene to a compound whose physical properties are already well known. The formulations for these compounds are given in Table 3.

TABLE 3

FORMULATIONS OF COMPOUNDS DESIGNED TO DETERMINE
THE EFFECT OF INCORPORATING POLY-ISOPRENE

Formulation No.	A2b-1	A2b-2	A2b-3	A2b-4
Neoprene	100.0	100.0	100.0	100.0
Zinc Oxide	5.0	5.0	5.0	5.0
Wingstay 'T'	3.0	3.0	3.0	3.0
N.B.C.	3.0	3.0	3.0	3.0
Sunaptic Acid	1.0	1.0	1.0	1.0
Aquarex SMO	0.5	0.5	0.5	0.5
Accelerator 833	1.0	1.0	1.0	1.0
Dibutyl Sebacate	5.0	5.0	5.0	5.0
Butyl Oleate	-	-	10.0	10.0
Poly-isoprene	-	-	-	10.0
Mistron Vapor	10.0	10.0	10.0	10.0
Sulphur	-	2.0	2.0	2.0

FACTUAL DATA (continued)TASK A, Phase 2, Part B (continued)

Plates were dipped according to standard procedure and cured for 60 minutes at 260°F. Physical properties were determined at room temperature, -50°C and, in the case of compound A2b-4, at -60°C. The results of these tests are given in Table 4.

Examination of these results shows that the addition of poly-isoprene does improve the low-temperature characteristics, but it is less effective than a low-temperature plasticizer. However, poly-isoprene has much less effect on the room-temperature modulus than a low-temperature plasticizer, although it does result in undesirably low room temperature tensile strength.

A further set of compounds was next prepared in which changes were made to correct the defective features already reported. The formulations of these compounds are given in Table 5.

Plates were dipped from these compounds according to standard procedure and cured for 60 minutes at 260°F. Physical properties were determined at room temperature, -60°C, -65°C, and -70°C. The results of these tests are given in Table 6.

A study of these results shows that the incorporation of poly-isoprene does tend to prevent freezing at low temperatures, although all compounds examined did freeze at -70°C.

TABLE 4

**PHYSICAL PROPERTIES OF COMPOUNDS A2b-1, A2b-2, A2b-3, AND A2b-4
TESTED AT ROOM TEMPERATURE, AT -50°C, AND AT -60°C**

Compound No.	Test Temp. (°C)	Modulus at 200% (psi)	Modulus at 400% (psi)	Modulus at 600% (psi)	Tensile Strength (psi)	Elongation at Break (%)
A2b-1	+20	125	175	260	2180	1150
	-50	1710	2065	4130	5000	640
A2b-2	+20	210	305	850	2590	820
	-50	2520	2750	-	4860	540
A2b-3	+20	150	180	370	1240	790
	-50	1110	1660	-	3630	550
A2b-4	+20	120	170	310	975	810
	-50	395	930	2220	3080	630
	-60	1500	2585	-	2930	450

TABLE 5
FORMULATIONS OF COMPOUNDS CONTAINING POLY-ISOPRENE

Formulation No.	A2b-5	A2b-6	A2b-7	A2b-8	A2b-9
Neoprene 750	90.0	90.0	90.0	90.0	100.0
Neoprene 571	10.0	10.0	10.0	10.0	-
Zinc Oxide	5.0	5.0	5.0	5.0	5.0
N.B.C.	3.0	3.0	3.0	3.0	3.0
Neozone 'D'	2.0	2.0	2.0	2.0	2.0
Sunaptic Acid	1.0	1.0	1.0	1.0	1.0
Merac	1.0	1.0	1.0	1.0	-
Accelerator 833	-	-	-	-	2.0
Aquarex SMD	0.5	0.5	0.5	0.5	0.5
Dibutyl Sebacate	6.25	6.25	6.25	6.25	6.25
Butyl Oleate	10.0	15.0	15.0	15.0	15.0
Poly-isoprene	20.0	20.0	20.0	20.0	20.0
Barak	0.15	0.15	0.15	0.15	0.15
Sulphur	0.3	0.3	0.6	0.9	0.6

TABLE 6

**PHYSICAL PROPERTIES OF COMPOUNDS A2b-5, A2b-6, A2b-7, A2b-8, AND A2b-9
TESTED AT ROOM TEMPERATURE, AT -60°C, AT -65°C, AND AT -70°C**

Compound No.	Test Temp. (°C)	Modulus at 200% (psi)	Modulus at 400% (psi)	Modulus at 600% (psi)	Tensile Strength (psi)	Elongation at Break (%)
A2b-5	+20	90	130	200	1070	950
	-60	2275	2855	-	4200	560
	-65	2785	2930	-	3380	460
	-70	-	-	-	-	frozen
	-70	2010	2010	2010	3090	750 *
A2b-6	+20	80	125	200	1070	870
	-70	2470	2530	-	3160	450
A2b-7	+20	100	150	260	1210	820
	-70	-	-	-	-	frozen
	-70	2500	2500	3660	3660	600 *
A2b-8	+20	100	150	280	1350	830
	-70	-	-	-	-	frozen
	-70	2470	2470	4060	4350	650 *
A2b-9	+20	80	120	185	1070	950
	-65	1440	2110	-	3280	500
	-70	-	-	-	-	frozen
	-70	1850	1900	2640	3440	660 *

* 100% pre-elongation

FACTUAL DATA (continued)TASK A, Phase 2, Part B (continued)

However, compound A2b-9 shows reasonably good properties at room temperature and at -65°C , and on pre-elongation it shows excellent elongation at -70°C .

The tendency to cold flow shown by most of the compounds may be a characteristic of the poly-isoprene compounds and should not necessarily be considered as objectionable. In spite of this condition, the samples always reach a satisfactory elongation which is not the case with 100%-neoprene-polymer compounds.

An additional set of plates was dipped using compound A2b-9, and these were cured for 90 minutes and 120 minutes at 260°F and 60 minutes and 90 minutes at 280°F . Physical properties were determined at room temperature and at -70°C . The results of these tests, together with the results obtained on the samples cured for 60 minutes at 260°F , are recorded in Table 7.

The results of these tests are somewhat inconclusive. Although none of the samples froze at the higher cure, they still exhibit considerable cold flow; but the samples cured 90 minutes and 120 minutes at 260°F both reached reasonably good breaking elongations.

TABLE 7

**PHYSICAL PROPERTIES OF COMPOUND A2b-9 CURED AT 260°F AND 280°F
TESTED AT ROOM TEMPERATURE AND AT -70°C**

Cure Time (mins)	Cure Temp. (°F)	Test Temp. (°C)	Modulus at 200% (psi)	Modulus at 400% (psi)	Modulus at 600% (psi)	Tensile Strength (psi)	Elongation at Break (%)
60	260	+20	80	120	185	1070	950
		-65	1440	2110	-	3280	500
		-70	-	-	-	-	frozen
		-70	1850	1900	2640	3440	660 *
90	260	+20	80	120	180	960	935
		-70	2360	2750	-	3860	490
120	260	+20	90	135	215	1060	870
		-70	2125	2690	-	3660	490
60	280	+20	90	140	230	1050	830
		-70	2930	3930	-	4260	430
90	280	+20	95	140	240	1140	840
		-70	3120	3920	-	4200	470

* 100% pre-elongation

FACTUAL DATA (continued)TASK A, Phase 2, Part B (continued)

It would appear that the combination of neoprene and poly-isoprene gives compounds with only moderately good physical properties. If these were 100%-neoprene-polymer compounds, they would be discarded; but since they do contain poly-isoprene, and because there is no knowledge of such a polymer combination having been used for balloons in flight, it is proposed to continue this line of investigation and make and fly balloons from compound A2b-9.

Part C: Other Materials

Kadox 515 is a finer particle size zinc oxide than is Kadox 72, although they are both French Process Zinc Oxides supplied by New Jersey Zinc Company. Since it has been impossible so far to solublize zinc oxide for use in neoprene latex compounds, it was thought that the use of a finer particle size material was at least a step in the right direction and might be expected to show an improvement in consistency if not in actual altitude performance. Two compounds, A2c-12 and A2c-22, were prepared, formulations for which are given in Table 8.

Plates were dipped from these compounds according to standard procedure and cured for 60, 90, and 120 minutes at 260°F. Physical properties were determined at room temperature, and the results of these tests are given in Table 9.

TABLE 8**FORMULATIONS OF COMPOUNDS CONTAINING FRENCH PROCESS ZINC OXIDES**

Formulation No.	A2c-1s	A2c-2s
Neoprene	100.0	100.0
Kadox 72	5.0	-
Kadox 515	-	5.0
N.B.C.	3.0	3.0
Neozone 'D'	2.0	2.0
Sunaptic Acid	1.0	1.0
Merac	1.0	1.0
Aquarex SMO	0.5	0.5
Dibutyl Sebacate	6.25	6.25

TABLE 9

PHYSICAL PROPERTIES OF COMPOUNDS A2c-1s AND A2c-2s
TESTED AT ROOM TEMPERATURE

Compound No.	Cure Time (mins)	Cure Temp. (°F)	Modulus at 200% (psi)	Modulus at 400% (psi)	Modulus at 600% (psi)	Tensile Strength (psi)	Elongation at Break (%)
A2c-1s	60	260	135	185	350	1290	760
	90	260	155	220	420	1550	790
	120	260	150	210	460	2300	850
A2c-2s	60	260	135	215	400	1800	850
	90	260	145	200	460	2160	840
	120	260	150	200	470	2100	850

FACTUAL DATA (continued)TASK A, Phase 2, Part C (continued)

A study of these results shows that compound A2c-2z is somewhat faster curing than compound A2c-1z and is relatively insensitive to the time of cure at 260°F between limits of 60 minutes and 120 minutes.

It was also observed that the rate of settling of the zinc oxide from compound A2c-2z was very much less than from compound A2c-1z. It can reasonably be assumed, therefore, that compound A2c-2z, will produce balloons showing much better uniformity of cure throughout the balloon film. Balloons were made from this compound, and the results of the flights are recorded in Task A, Phase 5.

* * *

A sample of Butoxy Ethyl Oleate, which is chemically identical with Butyl Cellosolve Oleate, was received from American Chemicals during this quarter. A standard compound, the formulation of which follows, was prepared from this material and given the formula number A2c-3P.

Compound A2c-3P

Neoprene	100.0
Zinc Oxide	5.0
N.B.C.	3.0
Neozone 'D'	2.0
Sunaptic Acid	1.0
Merac	1.0
Aquarex SMO	0.5
Dibutyl Sebacate	6.25
Butoxy Ethyl Oleate	22.5

FACTUAL DATA (continued)TASK A, Phase 2, Part C (continued)

Plates were dipped and given the standard cure of 60 minutes at 260°F. Physical properties were determined at room temperature and at -70°C, and the results of these tests are given in Table 10.

TABLE 10PHYSICAL PROPERTIES OF COMPOUND A2c-3P
TESTED AT ROOM TEMPERATURE AND AT -70°C

Test. Temp. (°C)	Modulus at 200% (psi)	Modulus at 400% (psi)	Modulus at 600% (psi)	Tensile Strength (psi)	Elongation at Break (%)
+20	120	225	300	1675	890
-70	2220	2885	-	4580	540

These tests indicate that this material is at least equal to, if not superior to, Butyl Cellosolve Oleate. Accordingly, balloons were made from this compound, and the flight results are recorded in Task A, Phase 5.

FACTUAL DATA (continued)TASK A (continued)Phase 3: Evaluation of Processing Techniques

Because of the extreme thinness of a balloon film as it approaches burst, there is the possibility that premature rupture can occur due to the presence of small agglomerates of compounding materials. These small agglomerates could exceed the thickness of the expanded balloon film and act as a point of rupture. Filtration of the latex compound through fine filter media could remove these particles, if they do exist, and should result in more uniform physical properties.

Therefore, a sample of felt, identified as Grade B/8797, was obtained from the American Felt Company. Compound A5-104, the formula for which is given in Task A, Phase 5 of this report, was prepared in the normal manner and then filtered through the felt sample. Plates were dipped from the strained compound and cured for 60 minutes at 260°F. Samples were cut from ten plates, and the physical properties were determined at room temperature. The results of these tests are given in Table 11.

A study of these results indicates that there is no improvement in uniformity compared with the unstrained compound. In addition, the tensile strength, in particular, is generally lower than is normally obtained with this compound. This suggests the possibility that straining through felt is actually removing certain ingredients necessary for obtaining the optimum physical properties.

TABLE 11**PHYSICAL PROPERTIES OF COMPOUND A5-104 AFTER STRAINING THROUGH FELT**

Plate No.	Modulus at 200% (psi)	Modulus at 400% (psi)	Modulus at 600% (psi)	Tensile Strength (psi)	Elongation at Break (%)
1	110	230	375	1825	920
2	95	225	360	1960	940
3	105	260	340	1880	920
4	105	220	380	2010	930
5	110	255	335	1915	930
6	95	220	350	2110	920
7	100	235	355	1880	930
8	105	265	370	1925	940
9	115	240	340	1970	910
10	110	235	365	1885	920

FACTUAL DATA (continued)TASK A, Phase 3 (continued)

Since a satisfactory cure can be obtained with only one part of zinc, it seems unlikely that the low tensile strength is the result of removal of Zinc Oxide. By the same token, the accelerator, Merac, is a liquid and cannot be removed by straining.

These initial results certainly suggest that further work must be done with strained compounds in an effort to determine the cause of the generally inferior properties and of the considerable variation which exists from plate to plate.

* * *

It is customary to attach a separate stem to meteorological balloons in order to provide the necessary small-diameter neck needed for attachment to inflation nozzles. It is possible to design a dipping form which will create a neck of the required diameter as an integral part of the balloon, but it will leave an opening at the opposite end.

This opening can be closed by capping or by simply cementing and sealing under pressure. The cementing can be accomplished either on the uncured film or on the cured film. It would seem that the integral neck would provide a stronger section in the area at which the load is attached. There would, consequently, be less danger of the separation of the radiosonde from the balloon or of rupture of the balloon in the neck area.

FACTUAL DATA (continued)TASK A, Phase 3 (continued)

Five balloons having an integral neck were manufactured from compound A5-105. This is a standard dual-purpose compound, the formulation for which is as follows:

<u>Compound A5-105</u>	
Neoprene	100.0
Zinc Oxide	5.0
N. B. C.	3.0
Neozone 'D'	2.0
Sunaptic Acid	1.0
Merac	1.0
Aquarex SMP	0.5
Dibutyl Sebacate	6.25
Butyl Cellosolve Oleate	22.5

The five balloons were identified as C20-ITW, C20-2TW, C29-1TW, C29-2TW, and C29-3TW.

Balloons C20-ITW and C20-2TW were cemented after curing, using MMM's EC-880 cement. The seal was clamped for 24 hours. Balloon C29-ITW was closed by cementing a cap made from the same compound as the uncured balloon with the same cement, drying for 24 hours, and then curing. Balloon C29-2TW was closed with Dow Corning Silastic RTV732 adhesive which was allowed to cure without clamping at room temperature.

Balloon C29-3TW was closed by inserting into the opening a cardboard ring of the same type normally used at the neck end and cementing a cap over the balloon and the ring. MMM's EC-880 cement was again used on this balloon, and the balloon was then cured.

FACTUAL DATA (continued)TASK A, Phase 3 (continued)

These five balloons were flown with a free lift of 1400 grams. Their physical characteristics and the flight results are given in Table 12.

TABLE 12FLIGHT RESULTS - BALLOONS WITH INTEGRAL NECKS

Balloon No.	Weight (grams)	Length (inches)	Day or Night Flight	Altitude at Burst (feet)	Ascensional Rate (feet/min.)
C20-1TW	765	90	Day	102,700	1093
C20-2TW	725	87	Day	105,300	1121
C29-1TW	780	96	Night	107,152	1055
C29-2TW	750	91	Night	111,089	1087
C29-3TW	795	93	Night	94,600	1002

It is immediately apparent that the performance of these balloons is extremely satisfactory. Four of the five reached altitudes of more than 100,000 feet, and all balloons had ascensional rates in excess of 1000 feet per minute. In view of the fact that these balloons would normally be expected to meet an altitude specification of not more than 90,000 feet, it would seem that any of these methods of clamping the opening of the balloon is feasible.

Additional balloons of this type should be flown since the greater strength of the neck could conceivably result in more consistent balloon performance

FACTUAL DATA (continued)TASK A (continued)Phase 4: Molecular Structure of Balloon Films

A preliminary conference was held with Dr. Herman Newstein, and a program was initiated. Dr. Newstein is at present organizing the practical work which is to be conducted with the electron microscope as well as X-ray diffraction equipment. The first results of this program will be reported at the end of the next quarter.

Phase 5: Development of Optimum Compounds

During the closing weeks of contract DA-36-039-SC-90747, a compound was developed which showed high promise since it possessed much higher elongation at room temperature and substantially higher elongation at -40°C. than any other compound hitherto investigated.

A few flights were conducted which confirmed the evidence of the physical properties, and additional balloons in the 1000-, 1500-, and 2500- gram ranges have now been flown. The formulation, having been assigned the new number A5-101, is repeated here for ease of reference:

Compound A5-101

Neoprene	100.0
Zinc Oxide	1.0
Antioxidant	3.0
N.B.C.	3.0
Sunaptic Acid	1.0
Aquarex SMO	0.5
Accelerator	1.0
Dibutyl Sebacate	5.0
Mistron Vapor	5.0

FACTUAL DATA (continued)TASK A, Phase 5 (continued)

Balloons were manufactured from this compound without difficulty in the three weight ranges already mentioned, and these were all flown with a free lift of 1600 grams. The characteristics of the balloons and their flight performance are given in Table 13.

A study of these results shows that the balloons in the 1000-gram range performed extremely well. Eleven flights were completed; and of the eleven, eight balloons (72.5%) reached altitudes of more than 110,000 feet, and five (45%) reached altitudes of more than 115,000 feet. Nine of these balloons had ascensional rates of over 1000 feet per minute, and the two balloons which were not tracked to the top of the flight also ascended at more than 1000 feet per minute.

The performance of the 1500-gram balloons is also extremely good, two of the three achieving altitudes of more than 130,000 feet and the remaining balloon failing to reach 120,000 feet by only 118 feet. In every case, the ascensional rate was more than 1100 feet per minute. It should be noted that a balloon travelling at 1100 feet per minute reaches an altitude of 121,000 feet in the same time as a balloon travelling at 1000 feet per minute reaches 110,000 feet. The higher altitude reached by the 1500-gram balloons did not, therefore, involve greater elapsed flight time.

TABLE 13

FLIGHT RESULTS - BALLOONS MANUFACTURED FROM COMPOUND A5-101

Balloon No.	Weight (grams)	Length (inches)	Day or Night Flight	Altitude at Burst (feet)	Ascensional Rate (feet/min.)
A9-2TJ *	1140	104	Night	121,949	973
A9-3TJ *	1240	110	Night	121,129	1031
A9-6TJ *	1205	109	Night	113,058	1022
B25-4TH*	1280	107	Night	109,038	1062
C5-1TH *	1275	103	Night	115,940	1036
C8-3TH *	1225	101	Night	112,041	954
C7-1TH *	930	106	Day	94,250	1082
C8-2TH *	1000	100	Day	103,478	1084
C8-5TH *	1055	112	Day	120,050	1190
A7-2TJ	920	97	Day	92,300**	1026
A8-6TJ	930	100	Day	118,504	1149
A8-8TJ	940	100	Day	114,173	1052
A8-9TJ	920	98	Day	95,590**	1030
F4-1TW	1470	123	Day	119,882	1118
F4-2TW	1580	132	Day	132,841	1165
F4-3TW	1490	131	Day	136,581	1156
A16-2AM	2365	181	Day	120,866	1001
A16-3AM	2365	178	Day	38,000	821
A16-5AM	2435	180	Day	133,104	1050

* Balloon was post-plasticised

** Top Intelligible Data

FACTUAL DATA (continued)TASK A, Phase 5 (continued)

The performance of the 2500-gram balloons is disappointing, in general being no better than that of the 1500-gram balloons. However, the limited number of flights made with both the 1500-gram and 2500-gram balloons makes it unwise to attempt to draw any conclusions, favorable or otherwise; and additional balloons of this type will be flown during the next quarter.

* * *

Five balloons containing Kadox 515 were also flown during this quarter. These balloons were made from compound A2c-2z as given in Table 8 in Task A, Phase 2, Part C of this report, this compound now being assigned the number A5-102. The balloons were in the 1000-gram class and were flown with a free lift of 1600 grams. Their characteristics and flight performance are given in Table 14.

TABLE 14

FLIGHT RESULTS - BALLOONS MANUFACTURED FROM COMPOUND A5-102

Balloon No.	Weight (grams)	Length (inches)	Day or Night Flight	Altitude at Burst (feet)	Ascensional Rate (feet/min.)
S10-1TJ	1010	103	Day	117,471	1148
S10-2TJ	985	94	Day	101,500	1103
S10-3TJ	1025	94	Day	106,000	1075
S10-4TJ	995	97	Day	100,200	1054
S10-5TJ	1055	99	Day	115,551	1141

FACTUAL DATA (continued)TASK A, Phase 5 (continued)

A study of these results shows that the performance is satisfactory but is not superior to that of balloons made from a compound containing a coarser particle size zinc oxide. In addition, the uniformity of performance is not noticeably better. However, the two longest balloons did reach the highest altitudes, and there appears to be justification for pursuing this investigation further.

* * *

A total of twelve balloons were flown from a compound containing Butoxy Ethyl Oleate. The balloons were made from compound A2c-3p, given on page 7 under Task A, Phase 2, Part C of this report, which was assigned the number A5-103.

The balloons, all in the 1000-gram class, were flown with a free lift of 1600 grams. Their characteristics and flight performance are given in Table 15.

From these results it can be seen that, excluding the balloon which burst on inflation, all balloons reached an altitude of more than 100,000 feet, and seven reached an altitude of more than 115,000 feet. All but one rose at more than 1000 feet per minute.

It may, therefore, be concluded that Butoxy Ethyl Oleate is a satisfactory low-temperature plasticizer for use in meteorological balloon compounds.

* * *

TABLE 15

FLIGHT RESULTS - BALLOONS MANUFACTURED FROM COMPOUND A5-103

Balloon No.	Weight (grams)	Length (inches)	Day or Night Flight	Altitude at Burst (feet)	Ascensional Rate (feet/min.)
C21-1TW	1210	108	Burst on inflation		
C21-2TW	1180	112	Night	108,694	1105
C21-3TW	1235	117	Day	119,902	1096
C21-4TW	1160	112	Day	121,063	1126
C21-5TW	1220	115	Night	124,311	1027
C21-6TW	1175	110	Night	119,226	1037
F17-1T	1015	105	Day	118,143	1134
F17-2T	1000	104	Day	100,200	1074
F17-3T	965	105	Day	116,339	1106
F17-4T	1010	104	Night	100,200	957
F17-5T	1005	101	Night	108,957	1056
F17-6T	995	103	Night	116,339	1036

FACTUAL DATA (continued)TASK A, Phase 5 (continued)

Four balloons in the 4000-gram class were manufactured from a standard compound which has been giving reliable results over the past year and a half. The formulation of this compound is as follows:

Compound A5-104

Neoprene	100.0
Zinc Oxide	5.0
N.B.C.	3.0
Neozone 'D'	2.0
Sunaptic Acid	1.0
Accelerator 833	1.0
Aquarex SMO	0.5
Dibutyl Sebacate	6.25

The balloons were made on a recently acquired dipping form. They were flown with a free lift of 2000 grams, and their characteristics and flight performance are given in Table 16.

TABLE 16FLIGHT RESULTS - BALLOONS MANUFACTURED FROM COMPOUND A5-104

Balloon No.	Weight (grams)	Length (inches)	Day or Night Flight	Altitude at Burst (feet)	Ascensional Rate (feet/min.)
C22-1AM	4490	245	Day	98,300*	967
C22-2AM	4425	235	Day	129,134	1061
F2-2AM	4220	244	Day	139,009	1101
F2-3AM	4335	245	Day	136,549	1061

* Top Intelligible Data

FACTUAL DATA (continued)TASK A, Phase 5 (continued)

Although somewhat higher altitudes were anticipated, these results are, nevertheless, encouraging. It has generally been the case, in the past, that the consistency of performance with balloons of this size is very poor. The results in Table 16 indicate that consistency can now be achieved, and it is particularly interesting to note that the shortest balloon was the one which failed to exceed 130,000 feet. Had this balloon been 10 inches longer, as were the others, it is reasonable to assume that it would have reached an altitude of at least 135,000 feet.

The possibilities of achieving consistent performance at these levels now seem very much brighter.

TASK B: EFFECT OF FLIGHT CONDITIONS ON BALLOON PERFORMANCEPhase 1: Behavior on Inflation and Rupture

No progress during this period.

Phase 2: Effect of Pre-Elongation

The effect of pre-elongation on neoprene compounds is well known. Since polymers other than neoprene, particularly natural rubber and poly-isoprene, are being investigated at this time, it becomes necessary to determine whether or not pre-elongation of these films also results in greater breaking elongations at low temperatures.

Preliminary tests using a natural-latex compound indicated that there is no change in the breaking elongation at -60°C

FACTUAL DATA (continued)TASK B, Phase 2 (continued)

when the test piece is pre-elongated 100%. However, certain difficulties were experienced during these tests, the major problem being that most of the test pieces broke at the head instead of the center of the test piece as is normally the case.

Further work with natural-latex films and with neoprene, poly-isoprene blends will, therefore, be conducted. It is not possible to draw any conclusions at this time.

Phase 3: Effect of Ozone

Balloons weighing 1000 grams manufactured from compound A5-101 performed extremely well, reaching altitudes substantially higher than is normal for this size balloon. The limited number of flights with 1500-gram balloons made from the same compound also performed extremely well.

It has already been shown that this compound has higher elongation at low temperatures than any other compound previously evaluated. In order to complete the information regarding this compound, its resistance to attack by ozone was determined and compared with that of compound A5-104.

The effect of increasing the amount of anti-ozonant in the compound was also investigated, and tests were conducted on compound A5-101 to which had been added an additional 3 parts and 5 parts of N.B.C. Both dumbbell test pieces and inflated

FACTUAL DATA (continued)TASK B, Phase 3 (continued)

patches were examined. Samples were elongated 50%, 100%, 200%, 300%, 400%, 500%, and 600%, and the time to rupture was measured using an ozone concentration of 40 parts per million. Results of these tests are given in Table 17.

A study of these results shows that at all elongations, regardless of whether dumbbells or patches are used, compound A5-104 is superior to A5-101. However, addition of a further 3 parts of anti-ozonant to A5-101 renders it equal or superior to A5-104 when dumbbells are tested and almost identical to A5-104 in patch testing. Addition of a further 2 parts of anti-ozonant improves the ozone resistance when dumbbells are tested but appears not to improve the ozone resistance of patches, and there are some indications that the ozone resistance becomes poorer.

It is not possible to directly correlate life in the ozone chamber with flight performance. All that can be said is that the ozone resistance of A5-104 is quite satisfactory. The ozone resistance of A5-101, which is only slightly inferior to that of A5-104, is probably also satisfactory, and it can clearly be raised to the same level as A5-104. There should, therefore, be no difficulties encountered when flying balloons made from A5-101 due to insufficient resistance to attack by ozone.

TABLE 17

OZONE RESISTANCE OF COMPOUND A5-101 WITH ADDITIONAL ANTIOXIDANT
COMPARED WITH COMPOUND A5-104

Compound No.	Test Piece	Time to failure in minutes at elongation of						
		50%	100%	200%	300%	400%	500%	600%
A5-104	Dumbbell	73	68	58	54	35	35	55
A5-101	Dumbbell	46	39	36	33	27	25	28
A5-101 plus 3 parts NBC	Dumbbell	117	109	83	66	57	58	59
A5-101 plus 5 parts NBC	Dumbbell	123	150	95	80	55	54	72
A5-104	Patch	95	32	15	18	17	17	15
A5-101	Patch	45	30	8	10	10	12	8
A5-101 plus 3 parts NBC	Patch	90	32	19	17	12	14	12
A5-101 plus 5 parts NBC	Patch	60	38	24	20	16	12	9

FACTUAL DATA (continued)TASK B (continued)Phase 4: Effect of Radiation

In order to complete the evaluation of compound A5-101, its behavior on exposure to infra-red radiation was observed. Samples made from compound A5-101 were cured for 90 minutes at 260°F, and some of the films were post-plasticized after curing.

Physical properties were determined at zero, -20°C, and -40°C on the unpost-plasticized films, and at zero, -20°C, -40°C, -60°C, and -70°C on the post-plasticized films. The tests were conducted without and in the presence of infra-red radiation. The results are recorded in Table 18.

A study of this table shows that, in the case of the unpost-plasticized film, infra-red radiation has no effect on the elongation at zero and increases the elongation at -20°C and -40°C. There is little effect on tensile strength or modulus at zero, and relatively little effect at -20°C. However, at -40°C, there is a substantial drop in modulus and tensile strength. This characteristic is calculated to result in uneven expansion under certain conditions of day-time flight and may produce erratic performance, particularly in balloons designed for very high altitudes. There is, however, no reason to believe that this compound will perform any worse than A5-104.

TABLE 18

EFFECT OF INFRA-RED RADIATION ON HIGH-ELONGATION COMPOUND A5-101

Post-Plasti-cized	Test Temp. (°C)	Infra-Red Radiation	Modulus at 200% (psi)	Modulus at 400% (psi)	Modulus at 600% (psi)	Tensile Strength (psi)	Elongation at Break (%)
No	0	No	215	260	495	2110	1000
No	-20	No	250	375	1000	2710	800
No	-40	No	500	915	3710	4085	640
No	0	Yes	210	270	435	1940	990
No	-20	Yes	235	345	690	2305	860
No	-40	Yes	325	585	1815	2865	730
Yes	0	No	110	130	160	685	1010
Yes	-20	No	135	155	215	1015	990
Yes	-40	No	160	210	335	1250	890
Yes	-60	No	255	440	1915	2930	700
Yes	-70	No	1505	2500	-	3640	510
Yes	0	Yes	95	115	170	475	1010
Yes	-20	Yes	115	150	190	530	930
Yes	-40	Yes	155	175	295	740	830
Yes	-60	Yes	200	285	775	1845	730
Yes	-70	Yes	460	625	-	1765	580

FACTUAL DATA (continued)TASK B, Phase 4 (continued)

After post-plasticizing, infra-red radiation has no effect at zero except to reduce the tensile strength. At -20°C and -40°C , the elongation is reduced on irradiation which is an unusual condition. This is accompanied by relatively little change in modulus but a sharp drop in tensile strength. At -60°C , the elongation increases slightly, and there is a considerable drop in modulus and tensile strength. At -70°C , there is a sharp increase in elongation, and a very great drop in modulus and a substantial drop in tensile strength.

Generally speaking, these characteristics are similar to those usually encountered, and there is no reason to believe that balloons made from this compound should be any less reliable than those made from compounds being used in production at the present time. They can, of course, be expected to achieve higher altitudes because of higher low-temperature elongations.

* * *

The effect of infra-red radiation on a natural-latex compound was also determined. This compound was cured for 90 minutes at 212°F and 90 minutes at 230°F , and tests were conducted at -40°C , -50°C , -60°C , and -70°C . The results of these tests are given in Table 19.

It was not possible to conduct tests at higher temperatures than -40°C since the breaking elongation was such that

TABLE 19

EFFECT OF INFRA-RED RADIATION ON NATURAL-LATEX BALLOON COMPOUNDS

Cure Time (mins)	Cure Temp. (°F)	Test Temp. (°C)	Infra-Red Radiation	Modulus at 200% (psi)	Modulus at 400% (psi)	Modulus at 600% (psi)	Tensile Strength (psi)	Elongation at Break (%)
90	212	-40	No	125	700	3200	4010	620
90	212	-40	Yes	135	790	3015	3475	640
90	212	-50	No	190	1120	3300	4100	620
90	212	-50	Yes	200	1130	-	3930	560
90	212	-60	No	320	960	2360	3810	650
90	212	-60	Yes	330	995	-	2130	580
90	212	-70	No	1425	2195	-	4000	500
90	212	-70	Yes	965	1190	3200	3700	620
90	230	-50	No	225	645	2330	3250*	700*
90	230	-50	Yes	225	620	2325	3940	700
90	230	-60	No	300	600	2000	2950	700
90	230	-60	Yes	150	225	1820	2725*	680*
90	230	-70	No	1470	2560	-	3575	500
90	230	-70	Yes	480	505	1730	2500*	660*

* Sample stretched beyond scale limits.

FACTUAL DATA (continued)TASK B, Phase 4 (continued)

the jaws reached the end of the travel before the specimen broke. Modifications to the jaws are being made in order to continue this study.

Analysis of Table 19 shows that natural-latex films are much less susceptible to the effects of infra-red radiation than are neoprene films. In all cases there is very little difference between the elongation, tensile strength, and modulus recorded with and without infra-red radiation.

It would seem, therefore, insofar as this characteristic is concerned, that natural-rubber balloons might be expected to have more consistent performance than neoprene balloons. In fact, this characteristic, coupled with the excellent low-temperature properties of natural rubber, indicates that this material should make extremely good meteorological balloons.

Unfortunately, the extremely poor ozone resistance of natural rubber more than offsets these advantages, rendering balloons liable to attack and rupture at approximately 90,000 feet. Improvement in the ozone resistance should lead to much better altitudes, and this line of investigation should be pursued if only from an academic viewpoint.

* * *

FACTUAL DATA (continued)TASK B, Phase 4 (continued)

The possibilities of reducing the effect of infra-red radiation by incorporation of infra-red reflecting materials was examined during the course of Contracts DA-36-039-SC-84925 and DA-36-039-SC-90747.

A few flights were conducted with balloons made from a compound which showed much less effect on irradiation than the standard compound. There was no improvement in altitude, but this need not be an unexpected result; for if the balloon reflects infra-red radiation to a greater degree, then it is a natural result for its temperature, and therefore its breaking elongation, to be reduced.

Additional work along these lines was undertaken; and five compounds were prepared, the formulations for which are given in Table 20.

Plates were dipped from each of these compounds and cured for 60 minutes at 260°F. Physical properties were determined at -40°C with and without infra-red radiation, and the results of these tests are given in Table 21.

A study of these results shows that a compound indicating the highest reflectance of infra-red radiation is B-4a-2. It is, therefore, proposed to manufacture balloons from this compound and to conduct flight tests using balloons made from a standard compound containing less Zinc Oxide as controls.

TABLE 20**FORMULATIONS OF COMPOUNDS CONTAINING INFRA-RED REFLECTING MATERIALS**

Formulation No.	Bla-1	Bla-2	Bla-3	Bla-4	Bla-5
Neoprene 750	90.0	90.0	90.0	90.0	90.0
Neoprene 571	10.0	10.0	10.0	10.0	10.0
Zinc Oxide	5.0	10.0	5.0	10.0	5.0
N.B.C.	-	-	-	3.0	3.0
Neozone 'D'	-	-	-	2.0	2.0
DPPD	2.0	2.0	2.0	-	-
Merac	1.0	1.0	1.0	1.0	1.0
Sunaptic Acid	1.0	1.0	1.0	1.0	1.0
Aquarex SMD	0.5	0.5	0.5	0.5	0.5
Dibutyl Sebacate	6.25	6.25	6.25	6.25	6.25
Titanium Dioxide	-	-	5.0	-	5.0

TABLE 21

EFFECT OF INFRA-RED RADIATION ON COMPOUNDS Bha-1 THROUGH Bha-5
TESTED AT -40°C

Compound No.	Infra-Red Radiation	Modulus at 200% (psi)	Modulus at 400% (psi)	Modulus at 600% (psi)	Tensile Strength (psi)	Elongation at Break (%)
Bha-1	No	260	640	3325	3760	620
	Yes	120	290	2120	2880	620
Bha-2	No	480	1210	-	3730	580
	Yes	445	800	3330	3330	600
Bha-3	No	385	795	3990	3990	600
	Yes	330	495	2510	3660	650
Bha-4	No	430	800	3450	4150	640
	Yes	300	500	2100	2970	660
Bha-5	No	290	640	2950	3700	610
	Yes	300	420	1895	3290	670

CONCLUSIONS

TASK A: PROPERTIES OF BALLOONS AND BALLOON FILMS

Phase 1: Study of the Literature

Nothing of interest was revealed by the study of current literature.

Phase 2: Evaluation of Raw Materials

Part A: Neoprene Polymers

At a conference with E. I. du Pont de Nemours personnel, new standards for meteorological balloon polymers were established, and Du Pont promised to attempt the production of the desired material.

Previous results obtained with Neoprene 673 were confirmed in a dual-purpose compound, and it was clearly established that highly crystalline polymers of this type are completely unsatisfactory for meteorological balloons.

Part B: Polymers other than Neoprene

Compounds based on a blend of neoprene and poly-isoprene were shown to be stable, and it was also shown that addition of poly-isoprene improved the low-temperature characteristics. Although the physical properties otherwise seem to be inferior to those of neoprene compounds which do not contain poly-isoprene, it is, nevertheless, proposed to continue this evaluation.

CONCLUSIONS (continued)TASK A, Phase 2 (continued)Part C: Other Materials

A compound containing Zinc Oxide--Kadox 515-- was shown to settle much more slowly than one containing Zinc Oxide--Kadox 72. This can be expected to provide greater uniformity of cure throughout a balloon film since the distribution of Zinc Oxide from top to bottom of the balloon will be more uniform.

Butoxy Ethyl Oleate from American Chemicals was shown to give compounds with low-temperature characteristics at least equal to those obtained by the use of Butyl Cellosolve Oleate.

Phase 3: Evaluation of Processing Techniques

The results obtained using felt as a filter medium for latex compounds were erratic and inconclusive, and additional work is indicated.

Balloons having an integral neck were flown with very satisfactory results. It would appear that an acceptable method of producing this type of balloon is almost developed.

Phase 4: Molecular Structure of Balloon Films

A program of X-ray diffraction and electron microscope studies of balloon films was inaugurated with the assistance of Dr. Herman Newstein.

CONCLUSIONS (continued)TASK A (continued)Phase 5: Development of Optimum Compounds

Flights conducted with 1000-gram balloons made from high-elongation compounds demonstrated the feasibility of consistently reaching altitudes of at least 110,000 feet with balloons of this size.

Altitudes in excess of 130,000 feet were achieved with 1500-gram balloons made from the same compounds, but the performance of 2500-gram balloons was no better than that of similar balloons made from standard compounds.

Balloons weighing 1000 grams made from a compound containing Kadox 515 performed satisfactorily but showed no improvement in consistency over standard balloons.

Balloons weighing 1000 grams made from a compound containing Butoxy Ethyl Oleate also performed very satisfactorily.

Four balloons weighing 4000 grams made from a standard compound were flown and showed better consistency than has heretofore been obtained with balloons of this size, although the altitudes were not as high as anticipated.

TASK B: EFFECT OF FLIGHT CONDITIONS ON BALLOON PERFORMANCEPhase 1: Behavior on Inflation and Rupture

No progress during this period.

Phase 2: Effect of Pre- Elongation

Difficulties with the test equipment rendered inconclusive the preliminary results obtained of the effect of pre-elongation on natural-latex films.

CONCLUSIONS (continued)TASK B (continued)Phase 3: Effect of Ozone

The ozone resistance of the recently developed, high-elongation compound was shown to be inferior to that of a standard compound. However, it was also shown that this deficiency can easily be corrected by increasing the amount of antiozonant in the compound.

Phase 4: Effect of Radiation

The effect of infra-red radiation on the same high-elongation compound referred to in Phase 3 was shown to be virtually the same as that on a standard compound.

It was shown that natural-latex compounds are much less affected by infra-red radiation than are neoprene compounds.

Incorporation of materials designed to reflect infra-red radiation was again shown to be possible, and one compound was selected for further evaluation in balloon flight testing.

PROGRAM FOR THE NEXT INTERVAL

TASK A: PROPERTIES OF BALLOONS AND BALLOON FILMS

Phase 1: Study of the Literature

The study of current literature will be continued.

Phase 2: Evaluation of Raw Materials

Part A: Neoprene Polymers

At least one sample of a new neoprene polymer will be submitted by Du Pont and will be evaluated during the coming quarter.

Part B: Polymers other than Neoprene

The evaluation of natural-latex and poly-isoprene latex will be continued, particularly the use of the latter in combination with neoprene.

The investigation of acrylic latices as reinforcing materials will be initiated.

Part C: Other Materials

The evaluation of liquid compounding ingredients as replacements for solid antiozonants and anti-oxidants will be inaugurated. These will be used in conjunction with the fine-particle-size zinc oxides.

Further work with Thiocarbanilide as a low-temperature curing agent will also be carried out.

Phase 3: Evaluation of Processing Techniques

The investigation of various filter media for straining compounds will be continued and extended.

Additional balloons with integral necks will be manufactured and submitted for flight testing. These will not necessarily be restricted to the same type as already flown.

PROGRAM FOR THE NEXT INTERVAL (continued)TASK A (continued)Phase 4: Molecular Structure of Balloon Films

The program for the study of X-ray diffraction and electron-microscope pictures will be begun during this quarter.

Phase 5: Development of Optimum Compounds

Additional new compounds will be prepared on the basis of the information obtained in other phases of this study, and balloons will be prepared for flight testing.

In particular, further balloons in the 1500- and 2500-gram ranges will be made from the high-elongation compound, and 4000-gram balloons made from this compound will be submitted for testing. The performance of the 1000-gram balloon will be confirmed by additional flights.

TASK B: EFFECT OF FLIGHT CONDITIONS ON BALLOON PERFORMANCEPhase 1: Behavior on Inflation and Rupture

Photographic studies of the inflation and rupture of balloons will be undertaken during this period.

Phase 2: Effect of Pre-Elongation

The effect of pre-elongation on all compounds which contain hitherto unevaluated polymers will be determined. In addition, further work will be carried out on the effect of pre-elongation on natural-latex compounds.

PROGRAM FOR THE NEXT INTERVAL (continued)TASK B (continued)Phase 3: Effect of Ozone

The ozone resistance of all newly examined polymers will be determined, and the use of liquid antiozonants will be evaluated as already mentioned in Task A, Phase 2, Part C.

Phase 4: Effect of Radiation

Balloons will be made from the compound showing the lowest infra-red absorption. If 1000-gram balloons perform satisfactorily, this investigation will be extended to larger balloons in order to determine whether or not high infra-red absorption at very high altitudes is responsible for the general failure of big balloons to reach their theoretical altitudes. The more consistent performance of large balloons recently obtained renders such a program much more feasible, and the results obtained should be of very considerable value.

IDENTIFICATION OF KEY TECHNICAL PERSONNEL

<u>Name</u>	<u>Number of Hours</u>
Alvin Jampole	318
Eric Nelson	241
Harding Wing	193

AD Accession No.
Kaysam Corporation of America, Paterson, N. J.
Study of Physical and Chemical Characteristics
of Balloons and Balloon Materials
By Eric Nelson, Edited by John Kantor
First Quarterly Progress Report, 31 May 1963
Pages 42-Tables, 21
Signal Corps Contract No. DA-36-039-AMC-02160(E)
Dept. of the Army Project No. 1AD-25001A-126-0104
Unclassified Report

Work was conducted on the following tasks:
TASK A: Properties of Balloons and Balloon Films.
The literature was continually reviewed and a
conference was held with E. I. du Pont de Nemours
on neoprene polymers. Neoprene 673, natural
latex and blends of neoprene and poly-isoprene
were investigated. Fine particle size zinc
oxide and a new plasticizer were examined and
the effect of straining compounds through felt
was evaluated. A method of making balloons with
integral necks was examined. A program for X-ray
diffraction and electron microscope study of bal-
loon film was initiated. Balloons were flight
tested to correlate laboratory results with flight
performance and very good results were obtained
with balloons made from a high elongation compound.
Very high altitude balloons also performed well.
TASK B: The Effect of Flight Conditions on Balloon
Performance. The effect of pre-elongation, ozone
and infra-red radiation on newly developed neoprene
compounds and natural latex and poly-isoprene-
neoprene blends was measured. Compounds designed
to show little infra-red radiation absorption
were formulated and evaluated.

Unclassified
Meteorological
Balloon Film
Development

USAERDL
Contract No.
DA-36-039-
AMC-02160(E)

METEOROLOGICAL DIVISION
SURVEILLANCE DEPARTMENT
U. S. ARMY SIGNAL RESEARCH & DEVELOPMENT LABORATORY

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